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Spatial Arrangement in Pearl Millet-groundnut Intercropping System Influences Productivity, Competition and Economics

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Abstract: Pearl millet (*Pennisetum glaucum* L.) is the sixth major grown crop next to wheat, rice, corn, barley and sorghum in the world. Pearl millet has a wider adaptability for different agroclimatic conditions and seasons, and it is even suitable for an intercropping system. Groundnut (*Arachis hypogea* L.) is *Leguminous* oilseed crop that can be cultivated as an intercrop with various crops for enhancement of productivity and efficient resource use. Based on the above facts, the present study was conducted at Research Farm of Centurion University of Technology and Management during summer season of 2022 to assess the effect of summer pearl millet + groundnut intercropping system on growth, productivity, and competitive ability of crops under south Odisha conditions. The treatments were, T_1: Pearl millet (PM) sole (45cm x10cm), T_2: Groundnut (GN) sole (30cm x 10cm), T_3: PM (45cm x 10cm) + GN (1:1), T_4: PM (45cm x 10cm) + GN (2:2), T_5: PM (30cm x 10cm)+ GN (1:1), T_6: PM (30cm x 10cm) + GN (2:2) , T_7: PM (60cm x 10cm) + GN (1:1), T_8: PM (60cm x 10cm) + GN (1:2) and T_9: PM (60cm x 10cm)+ GN (1:3). The experiment was laid out in Completely Randomized Block Design (CRBD) and replicated thrice. The Results revealed that the maximum values of growth-attributing characters of both pearl millet and groundnut during sole cropping were observed. However, Among the yield attributes of pearl millet, 1000 grain weight showed a non-significant difference. Moreover, the treatment pearl millet (60 cm x 10 cm) + groundnut (1:1) obtained the highest yield attributing characters and yield. The results concluded that pearl millet and groundnut could be intercropped with 1:1 row proportion with pearl millet spacing of 45 cm x 10 cm in south Odisha conditions for a greater resource use, higher total productivity and economic benefit.

Introduction

Intercropping is a sustainable cropping system where two or more crops are grown together on the same piece of land designed to optimize the use of resources like land, water, nutrients, sunlight while minimizing the risk of total crop failure due to biotic and abiotic stresses (Maitra et al., 2019; Maitra, 2020; Mir et al., 2022; Hemasree et al., 2025). By encouraging a complementary interaction between crops in terms of growth patterns and resource requirements, intercropping can enhance biodiversity, improve pest and disease control, reduce weed pressure and lead to more stable yields under variable environmental conditions (Dwivedi et al., 2015; Maitra et al., 2021; Nandi et al., 2022; Maitra *et al*., 2023a,b). It also supports soil fertility improvement through better nutrient recycling, particularly when legumes are involved in the system. Among various intercropping systems, cereal-legume combinations are highly effective due to their complementary roles in nutrient utilization. Cereals typically require higher nitrogen inputs, while legumes,

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through biological nitrogen fixation, improve soil fertility and benefit their companion crops (Ghosh et al., 2007; Maitra et al., 2020; Mukesh et al., 2024; Guntamukla et al., 2024). Pearl millet (*Pennisetum glaucum* L.) is a nutri-cereal recognized for its drought tolerance, hardiness in poor soils, and resilience to extreme climates. It is well-suited for dryland and semi-arid regions, making it an ideal crop for resource-constrained environments. Beyond its food value, it is a valuable feed and fodder crop. In spite of its advantages, pearl millet occupies only 1870 ha of land in Odisha and its productivity is far below the national average of 1436 kg ha^{-1} over 7.57 million ha (GOI, 2021; GoO, 2020).

Groundnut (*Arachis hypogaea* L.), a widely cultivated oilseed and legume crop, offers high nutritional and economic value. It contains 29% fat, 28% protein and 20% carbohydrates, making it a vital source of calories and protein in many regions (Hussainy et al., 2020). Additionally, its ability to fix atmospheric nitrogen makes it an excellent companion crop for cereals in intercropping systems. Nationally, groundnut covers 6.09 million ha, producing 10.21 million t at an average yield of 1676 kg/ha (GOI, 2021). Odisha's share includes 6.02 lakh ha of oilseeds, producing 5.69 lakh tonnes with a productivity of 945 kg/ha (GoO, 2020).

With increasing concerns over land degradation, declining soil health climate change impacts and the challenge of feeding a growing population, sustainable intensification through intercropping has gained prominence (Sairam et al., 2023; Santosh et al., 2024; Maitra and Ray, 2019; Gaikwad et al., 2022; Gitari et al., 2020; Maitra et al., 2023a,b). Intercropping systems are recognised to boost overall productivity per unit area and reduce production risks by diversifying crops within the same growing period (Sarkar et al., 2000; Maitra et al., 2000 Maitra et al., 2001a,b; Maitra et al., 2020; Ray et al. 2025). When component crops differ significantly in growth duration, rooting depth, or nutrient and light requirements, the complementarity leads to better resource partitioning and improved yields (Nandi et al., 2022). The research on pearl millet and groundnut intercropping systems is meagre in South Odisha. Hence, an attempt was made to assess the feasibility and benefits of pearl millet-groundnut intercropping systems with different row proportions and spacing arrangements under South Odisha conditions.

Materials and Methods

A field study was carried out during the summer 2022 at the P.G. Research Farm of Centurion University of Technology and Management (CUTM). Weather data for the crop season from March 3 to June 27, 2022, were obtained from the meteorological observatory at the CUTM as shown in Table 1. The study field had a sandy loam textured soil, pH of 6.3 and 0.34% OC. The initial soil contained 226, 13.8 and 125.4 kg/ha of primary nutrients namely, N, P and K, respectively.

The trial was designed in CRBD and included nine treatments, namely, T_1: PM (PM) sole (45cm x10cm), T_2: GN (GN) sole (30cm x 10cm), T_3: PM (45cm x 10cm) + GN (1:1), T_4: PM (45cm x 10cm) + GN (2:2), T_5: PM (30cm x 10cm) + GN (1:1), T_6: PM (30cm x 10cm) + GN (2:2), T_7: PM (60cm x 10cm) + GN (1:1), T_8: PM (60cm x 10cm) + GN (1:2) and T_9: PM (60cm x 10cm)+ GN (1:3) with 3 replications. In each replication, there were nine plots having a net size of 4.5 m x 3.6 m each. Pearl millet hybrid 'PA 9285' and groundnut variety 'K6' were chosen for the experimentation. Sole pearl millet was seeded at 45 cm x10 cm spacing and sole groundnut was sown with 30 cm x 10 cm spacing. In intercropped treatments, legumes were sown 1, 2 and 3 rows in between pearl millet as per treatments. The recommended fertilizer dose for PM sole and intercropped treatments was 60-30-30 kg/ha of N: P_2O_5 : K_2O, and for GN sole, it was 20-40-20 kg/ha, respectively. In PM sole crop and pearl millet + groundnut intercropping plots, 50% of the total nitrogen dose was applied as basal dose along with the whole amount of phosphate and potash, whereas, all fertilizers were applied as basal doses in sole groundnut. Prior to planting, these fertilizers were incorporated into the soil. PM sole crop and pearl millet + groundnut plots received the second-half of the nitrogen at 30 DAS. Two hand weedings were done at 15 and 30 DAS for weed management. For the successful raising of crops, three irrigations were applied. The growth and yield parameters of pearl millet and groundnut, along with the yields of both component crops, were recorded following standard agronomic methodologies. Competitive indices such as the Land Equivalent Ratio (LER), Area Time Equivalent Ratio (ATER), Monetary Advantage Index (MAI) and Maize Equivalent Yield (MEY) were computed based on the standard formulae (Maitra, 2023). The data recorded were analysed as suggested by Gomez and Gomez (1984) and the software used for the purpose was Microsoft Excel (Microsoft Corp., Redmond, WA, USA).

Results and Discussion

Growth attributes

Intercropping of pearl millet (PM) and groundnut (GN) showed a significant variation in the expression of plant height and dry matter accumulation of both crops at 30 and 60 DAS (Table 2). The tallest plants of pearl millet at 60

DAS was observed in PM (30 cm x10 cm) + GN (1:1) and this treatment was statistically at par with PM (45 cm x10 cm) + GN (1:2) (150 cm), PM (60 cm x10 cm) + GN (1:3) (147cm) and PM (45 cm x10 cm) + GN (1:1) (145 cm); however, the remaining treatments were significantly inferior in expression of plant height. The lowest plant height was obtained in PM (60 cm x10 cm) + GN (1:2) (136 cm). The plant height at 90 DAS was also obtained highest in pearl millet (30 cm x10 cm) + GN (1:1), which remained statistically like PM (45 cm x10 cm) + GN (1:2) and PM (45 cm x10 cm) + GN (1:1). However, the lowest plant height was obtained in PM (60 cm x10 cm) + GN (1:1). The highest plant height in PM (30 cm x10 cm) + GN (1:1) could be due to less spacing and more accommodation of plants/m^2. Probably there was more competition between the crops resulted in more stem elongation in pearl millet. These results are supported by earlier research works of Chaudhary et al. (2020) and Rani et al. (2017).

In the case of groundnut, at 60 DAS, the highest plant height was recorded in PM (45 cm x10 cm) + GN (1:2) (43cm), and it was statistically at par with PM (60 cm x10 cm) + GN (1:3) (42 cm), PM (30 cm x10 cm) + GN (1:1) (41 cm) and GN sole (30 cm x 10 cm) (40 cm). The lowest plant height was recorded in PM (30 cm x10 cm) + GN (2:2) (36 cm). The treatment PM (45 cm x10 cm) + GN (1:2) showed its significant superiority over PM (45 cm x10 cm) + GN (1:1), PM (30 cm x10 cm) + GN (2:2) and PM (60 cm x10 cm) + GN (1:1). At 90 DAS, the treatment PM (45 cm x10 cm) + GN (1:2) obtained significantly higher plant height of GN (65 cm) over all the treatments. Pearl millet provided partial shade to groundnut and created a favourable microclimate for groundnut to obtain a higher plant height by stem elongation.

In the case of dry matter accumulation by pearl millet at 60 DAS, the highest values were recorded in PM sole (45 cm x10 cm) (538 g/m^2) and this treatment was found to be significantly superior to all other intercropping treatments (Table 2). However, the lowest dry matter accumulation was recorded in PM (60 cm x 10 cm) + GN (1:3) (171.60 g/m^2). At 90 DAS, the same trend was noted where PM sole (45 cm x10 cm) recorded the highest DMA (857 g/m^2) and it was followed by PM (45 cm x10 cm) + GN (1:1) (816 g/m^2); however, both treatments were statistically at par. Moreover, the remaining intercropping treatments were inferior to the above-mentioned treatments. During all the growth stages, PM sole obtained the highest dry matter production as there was no inter-species competition and optimum plant stand. Overall, the intercropping treatment PM (30 cm × 10 cm) + GN (1:1) consistently performed better for both crops in terms of plant height and dry matter accumulation, demonstrating

Table 1. Meteorological parameters from February 2022 to June 2022.

Standard week	Period	Temperature (˚C)		Relative humidity (%)	Rainfall (mm)	Sunshine (hrs./day)
		Max.	Min.			
February 2022						
9th	26 Feb-04 Mar	34	18	92	0.0	8.9
March 2022						
10th	05 Mar-11 Mar	36	18	88	0.0	8.6
11th	12 Mar-18 Mar	37	19	87	0.0	9.0
12th	19 Mar-25 Mar	36	23	92	0.9	8.7
13th	26 Mar-01 Apr	37	27	90	0.0	9.1
April 2022						
14th	02 Apr-08 Apr	36	26	88	0.0	9.9
15th	09 Apr- 15 Apr	38	26	89	0.0	10.0
16th	16 Apr – 22 Apr	38	27	87	0.0	10.0
17th	23 Apr- 29 Apr	41	26	88	0.0	11.0
18th	30 Apr – 06 May	37	26	88	0.8	10.0
May 2022						
19th	07 May-13 May	35	25	91	10.8	9.3
20th	14 May- 20 May	37	28	90	0.0	10.0
21st	21 May-27 May	37	26	89	4.0	9.9
22nd	28 May- 03 June	38	28	89	0.1	10.4
June 2022						
23rd	04 June-10 June	36	27	88	0.5	10.0
24th	11 June- 17 June	35	25	90	3.7	9.6
25th	18 June-24 June	34	25	92	4.1	9.0
26th	25 June- 01 Jul	33	25	92	3.1	8.9

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its potential for higher productivity through efficient resource utilization. At 60 DAS and 90 DAS, the highest dry matter production of groundnut was noted with GN sole (30 cm x 10 cm) (486 g/m^2 and 683 g/m^2 respectively) and it registered a significant superiority over the mixed stands. The dry mass produced by GN sole was closely trailed by PM (30 cm x10 cm) + GN (1:1) (154 g/m^2), PM (60 cm x10 cm) + GN (1:2) (126.40 g/m^2) and PM (45 cm x10 cm) + GN (1:1) (123.90 g/m^2). Moreover, the least dry matter production was observed in PM (30 cm x10 cm) + GN (2:2) (97 g/m^2). As a 100 per cent population was maintained in the case of GN sole, it was able to obtain maximum dry matter production. Earlier Raman et al. (1991), Mandal et al. (1989) and Chappa et al. (2023) reported similar results.

x10 cm) (1.74) and the lowest in PM (60 cm x10 cm) + GN (1:3) (0.79).

In the case of groundnut, the data narrated that the treatment PM (30 cm x10 cm) + GN (1:1) registered the highest LAI of groundnut at 60 and 90DAS (Figure 2). This treatment was closely followed by GN sole (30 cm x 10 cm) and PM (45 cm x10 cm) + GN (1:2). The maximum LAI in the mixed stand was probably due to the legume effect of groundnut and partial shade provided by pearl millet. However, the second highest LAI in GN sole was probably due to the efficient utilization of nutrients in optimum plant density and because of the absence of interspecies competition. Earlier reports by El-Aref Kh et al. (2019) and Manasa et al. (2021), showed similar findings in the mixed stand of cereals and legumes.

Table 2. Plant height and dry matter accumulation of pearl millet and groundnut at 60 and 90 DAS.

Treatments	Plant height (cm)				Dry matter production (g/m^2)			
	60 DAS		90 DAS		60 DAS		90 DAS	
	PM	GN	PM	GN	PM	GN	PM	GN
PM Sole (45 cm x10 cm)	143	-	167 ^{bcd}	-	538	-	857	-
GN sole (30 cm x 10 cm)	-	40	-	60	-	486	-	683
PM (45 cm x10 cm) + GN (1:1)	145	37	177	56	472	345	776	553
PM (45 cm x10 cm) + GN (1:2)	150	43	179	65	330	356	649	565
PM (30 cm x10 cm) + GN (1:1)	154	41	186	60	411	439	748	664
PM (30 cm x10 cm) + GN (2:2)	141	36	167	57	301	215	632	341
PM (60 cm x10 cm) + GN (1:1)	139	37	163	59	313	264	637	393
PM (60 cm x10 cm) + GN (1:2)	136	38	165	58	243	355	554	517
PM (60 cm x10 cm) + GN (1:3)	147	42	170	61	172	352	508	509
S.Em. ±	4.34	1.4	5.1	1.7	15.1	13.9	24.5	20.7
C.D. (p=0.05)	13.2	4.2	15.5	4.9	45.9	42.1	74.3	62.7

PM=Pearl millet; GN=Groundnut

At 60 DAS, there was a significant influence of intercropping treatments on LAI (Figure 1) where the highest LAI was observed in sole PM (45 cm x10 cm) (2.19) and it was followed by PM (45 cm x10 cm) + GN (1:1) (2.09) and PM (30 cm x10 cm) + GN (1:1) (2.08); however, they were statistically at par with sole PM (45 cm x10 cm) (Figure 1). The lowest LAI was obtained in PM (60 cm x10 cm) + GN (1:3) (1.84) at the same stage. At harvest, the LAI of pearl millet was decreased due to natural senescence as the crop reached its maturity. However, the highest LAI was recorded in PM sole (45 cm

Yield attributes

The yield attributes of pearl millet, namely, ear head length, ear head diameter, and weight of grains/plant, were significantly influenced by intercropping ratios (Figure 3). Among the treatments, the highest values of highest ear head length (24.31 cm), ear heat diameter (4.85 cm) and weight of grains/plant (13.12 g) were observed in PM (60 cm x10 cm) + GN (1:1) which was closely followed by PM (60 cm x10 cm) + GN (1:2) and PM sole (45 cm x10 cm). The lowest values of the above-mentioned yield attributes were obtained in PM (30 cm x10 cm) + GN (1:1). The enhancement of yield attributes with the formerly

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mentioned treatments was probably because of the wider row spacing and sufficient availability of resources that helped the plants to ensure better growth and ultimately reflected into the increased ear head length. The above findings conform to the research outcomes of Lal et al. (2018) and Priya et al. (2024).

results corroborate with the findings of Hussainy et al. (2019) and Hussainy and Vaidyanathan (2019). Moreover, GN sole noted the highest weight of pods/plant and this treatment was closely followed by PM (45 cm x10 cm) + GN (1:1), PM (60 cm x10 cm) + GN (1:2).

Yield

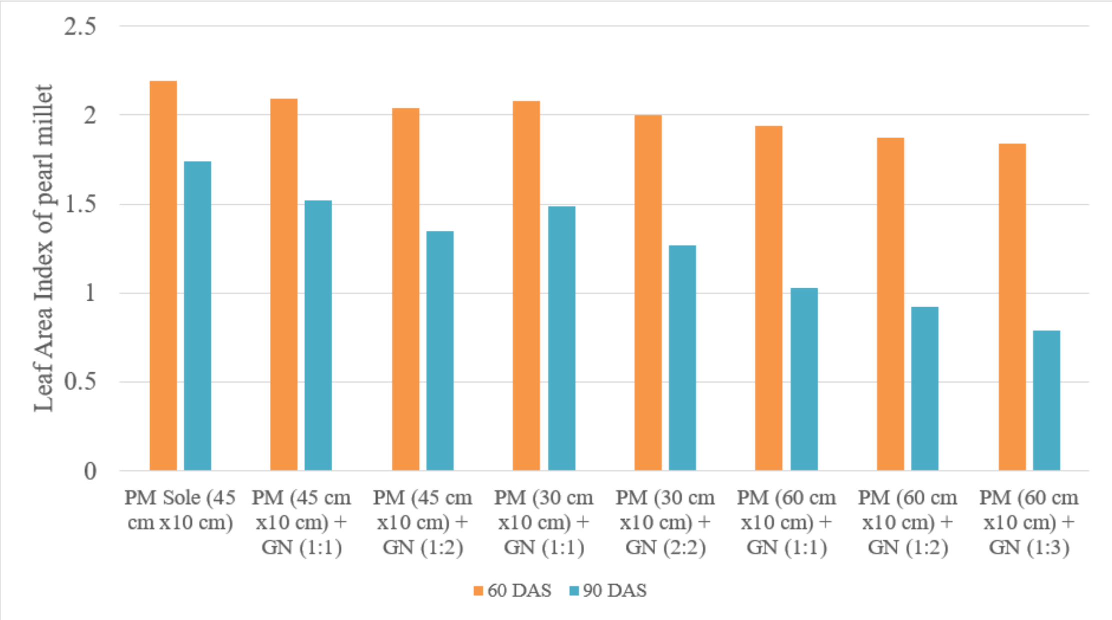

Figure 1. Effect of pearl millet-groundnut intercropping on leaf area index of pearl millet.

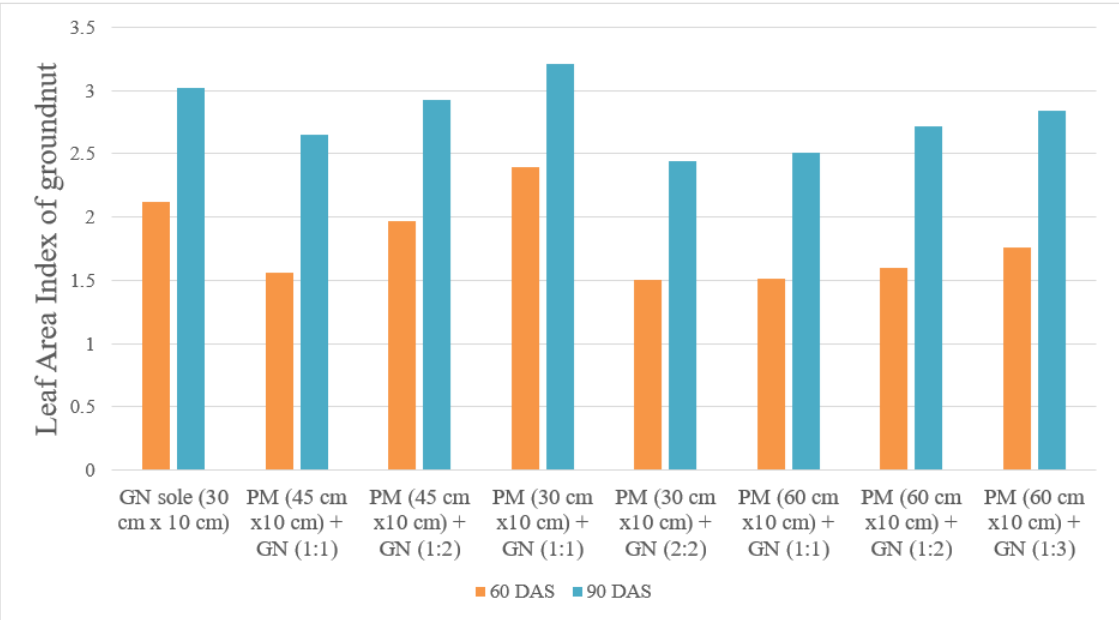

Figure 2. Effect of pearl millet-groundnut intercropping on leaf area index of groundnut.

In the case of groundnut, the number of pods/plant and number of kernels/pod were recorded as the highest values in treatment with PM (60 cm x10 cm) + GN (1:1) (Figure 4). Further, this treatment was closely followed by PM (45 cm x10 cm) + GN (1:1) and GN sole (30 cm x 10 cm). Such results were recorded probably due to the wide row alignment, the least competition for available resources and complimentary interaction between crops in the case of the treatment PM (60 cm x10 cm) + GN (1:1). The

Grain, stover, and biological yield of PM were recorded in PM sole, and it remained significantly higher than the mixed stands (Figure 5). Among the mixed stands, PM (45 cm x10 cm) + GN (1:1) performed well in expression of yield of PM, which was closely followed by PM (30 cm x10 cm) + GN (1:1) PM (45 cm x10 cm) + GN (1:2). Pearl millet yield of the treatment consisting of PM (45 cm x10 cm) + GN (1:1) was significantly higher than other mixed stands. The plant stand of PM remained 100% in PM sole

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and PM (45 cm x10 cm) + GN (1:1); however, PM sole was void of any competition between plant species and used the available resource properly. Probably, it might be a suitable reason for the yield enhancement of pearl millet in its pure stand. Further, PM sole (45cm x 10 cm) registered higher dry matter production, leaf area index and number of grains per ear head which might be reflected in the yields of pearl millet. Similar findings were noted by earlier researchers (Triveni, 2017; Priya et al., 2024).

yields were recorded in the pure stand of GN was because of 100% plant population, however, in the intercropping treatments, the plant stand of GN was reduced as per row ratios and spatial arrangements. The yield variation with the mixed stands was recorded because of changes in plant population, planting geometry, and competitive and complementary effects. The results corroborate the findings of Shwethanjali et al. (2018) and Khan et al. (2017).

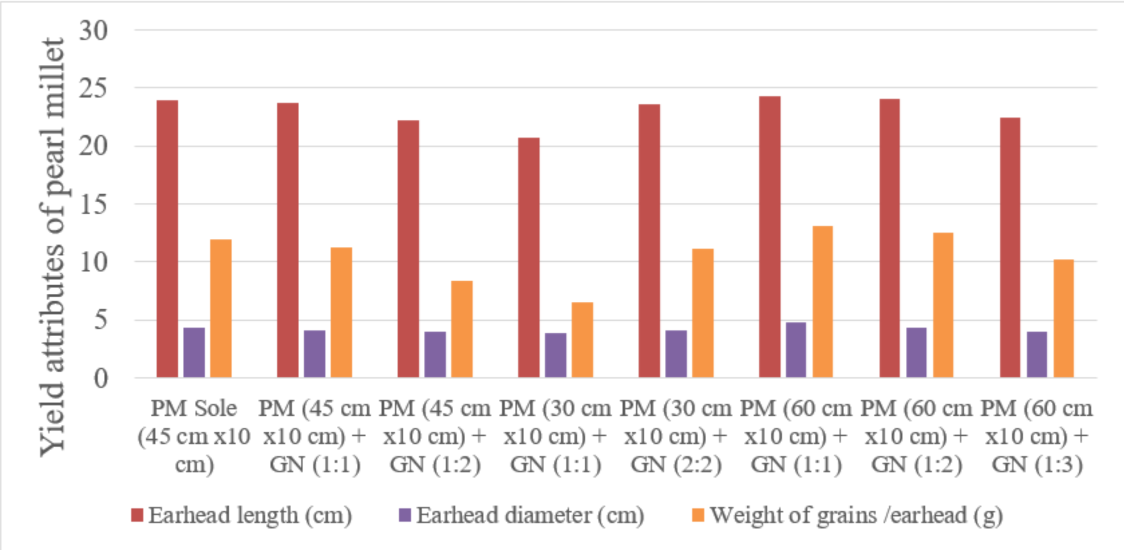

Figure 3. Effect of pearl millet-groundnut intercropping on yield attributes of pearl millet.

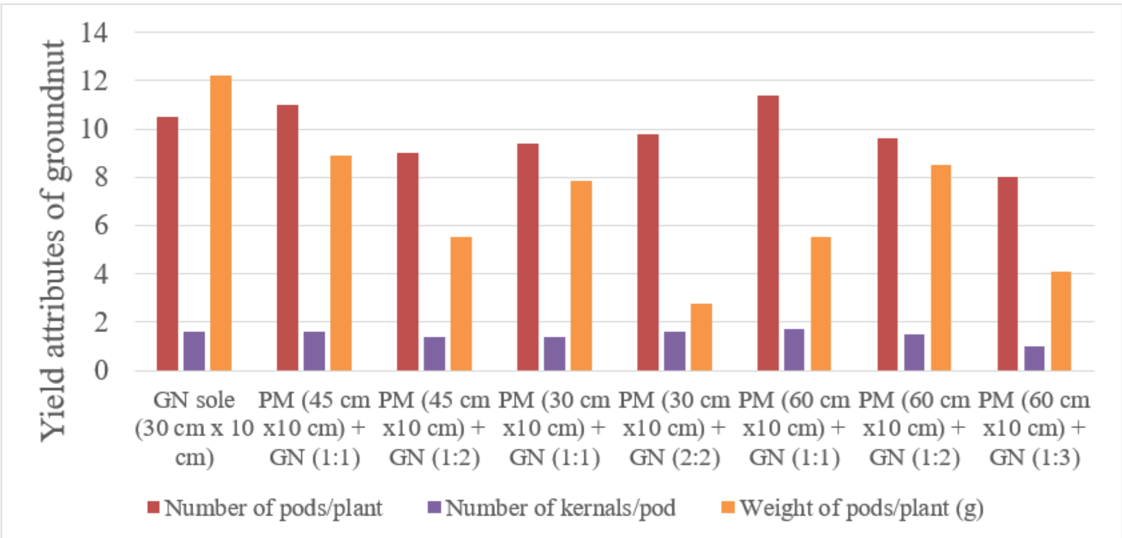

Figure 4. Effect of pearl millet-groundnut intercropping on yield attributes of groundnut.

There was a remarkable difference among treatments in the expression of pod, stover and biological yields of groundnut (Figure 6). The results revealed that the highest yields of groundnut were recorded in GN sole (30 cm x 10 cm), and it was superior to other treatments because the pure stand of GN had a 100% population of groundnut. Among the mixed stands, the highest pod, stover and biological yield of groundnut were noted with PM (60 cm x10 cm) + GN (1:2) followed by PM (45 cm x10 cm) + GN (1:1) and PM (45 cm x10 cm) + GN (1:1). The highest

Competition functions

The evaluation of intercropping systems using various indices such as Land Equivalent Ratio (LER), Area Time Equivalent Ratio (ATER), Aggressivity, Relative Crowding Coefficient (RCC) and Competitive Ratio (CR) revealed significant insights into the performance and compatibility of PM and GN combinations (Figure 7). The combined LER values were greater than one in most treatments, indicating yield advantages over sole cropping, with the highest value recorded in PM (30 cm x 10 cm) +

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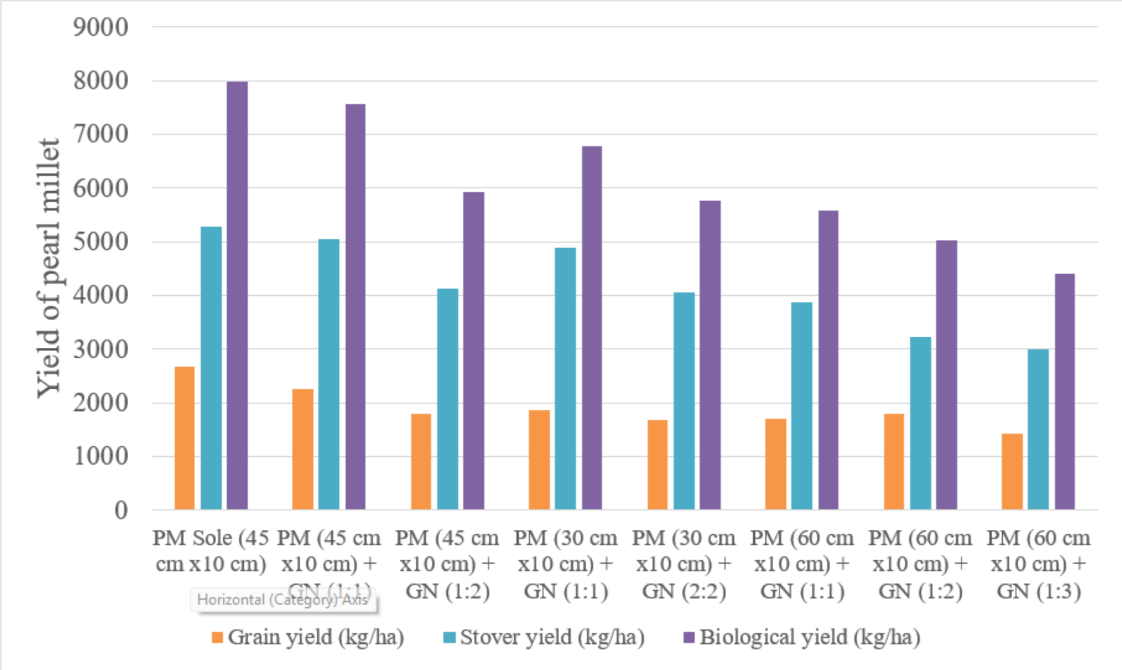

Figure 5. Pearl millet-groundnut intercropping system influenced on pearl millet yield.

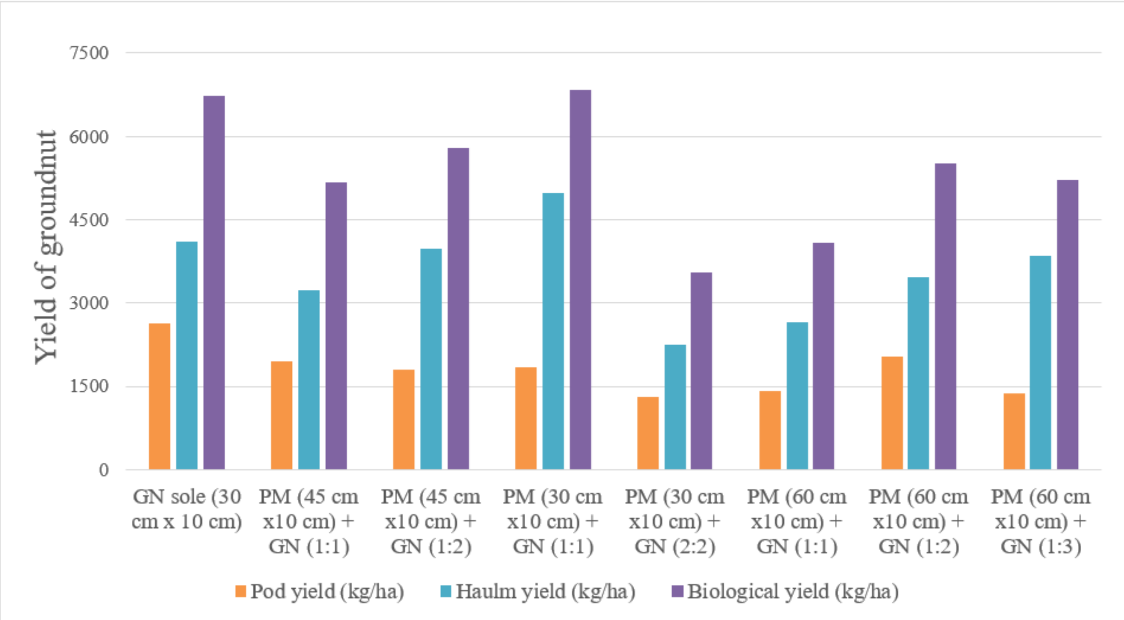

Figure 6. Effect of pearl millet groundnut intercropping on yield of groundnut.

GN (1:1) (1.75), followed by PM (45 cm x 10 cm) + GN (1:2) (1.59). Similarly, the ATER values reflected superior land-use efficiency when time was accounted for, with the same treatment (PM + GN in 1:1 proportion at 30 cm row spacing) achieving the highest ATER (1.49). Aggressivity analysis showed that in some combinations pearl millet was dominant, while in others groundnut dominated, emphasizing the role of crop geometry and proportion in determining competitiveness. The RCC further confirmed intercropping benefits, as treatments with K values above one, particularly PM (30 cm x 10 cm) + GN (1:1) (12.23), outperformed others. The CR values also supported this, highlighting either crop's competitiveness depending on treatment, with notable mutual competitiveness in PM (30 cm x 10 cm) + GN (1:1). These results collectively suggest that intercropping, especially with balanced proportions and optimal spacing, offers significant biological and economic advantages, aligning well with findings of previous researchers like Arif et al. (2022) and Mohamed et al. (2020).

Crop equivalent yield

Different intercropping treatments had a good influence on pearl millet equivalent yield and are present-

Table 3. Effect of intercropping system on pearl millet equivalent yield (PEY) and groundnut equivalent yield (GEY).

Crop equivalent yield (kg/ha)		
Treatments	**Pearl millet equivalent yield (PEY)**	**Groundnut equivalent yield (GEY)**
PM (45 cm x10 cm) + GN (1:1)	6307	3027
PM (45 cm x10 cm) + GN (1:2)	5577	2677
PM (30 cm x10 cm) + GN (1:1)	5713	2742
PM (30 cm x10 cm) + GN (2:2)	4419	2121
PM (60 cm x10 cm) + GN (1:1)	4673	2243
PM (60 cm x10 cm) + GN (1:2)	6061	2909
PM (60 cm x10 cm) + GN (1:3)	4299	2064
PM=Pearl millet; GN=Groundnut		

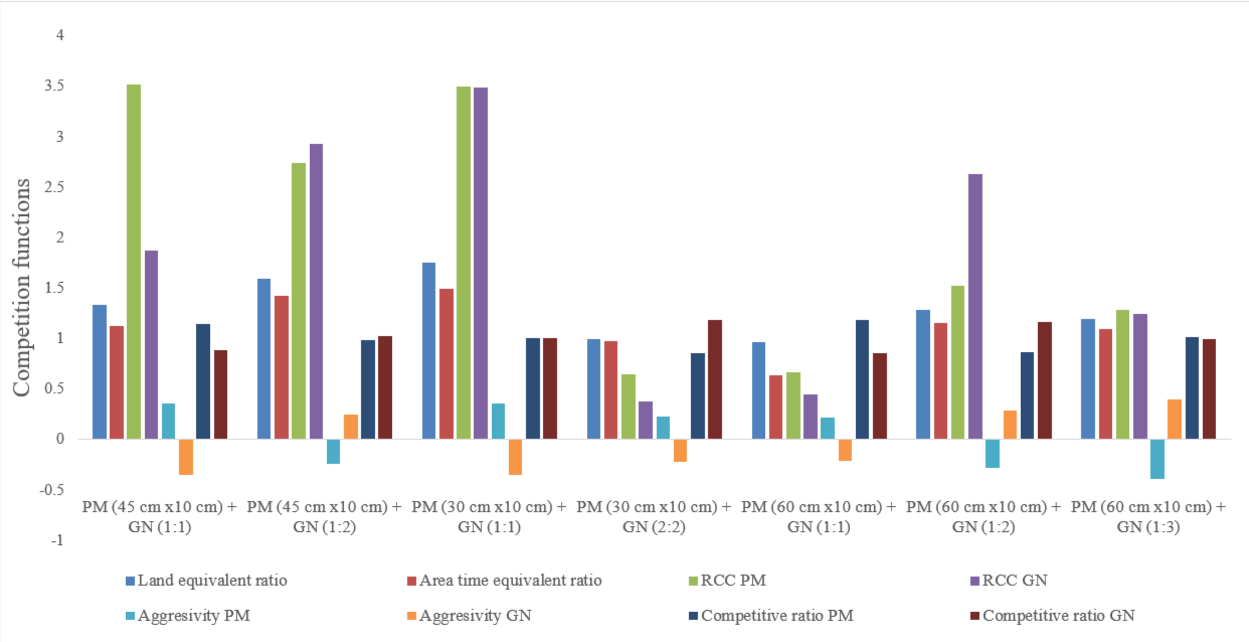

Figure 7. Effect of pearl millet-groundnut intercropping system on competition functions.

-ed in Table 3. The highest value of pearl millet equivalent yield was registered in PM (45 cm x10 cm) + GN (1:1) (6307 kg/ha), followed by PM (60 cm x10 cm) + GN (1:2) (6061 kg/ha), PM (30 cm x10 cm) + GN (1:1) (5713 kg/ha) and PM (45 cm x10 cm) + GN (1:2) (5577 kg/ha). The plant population of groundnut, planting geometry and complementary effects between the crop species probably influenced the pearl millet equivalent yield. In this regard, earlier Rawat *et al*. (2017) and Yadav *et al*. (2015) reported similar findings. The intercropped treatment of PM (45 cm x10 cm) + GN (1:1) recorded the highest groundnut equivalent yield of (3027 kg/ha) followed by PM (60 cm x10 cm) + GN (1:2) (2909 kg/ha), PM (30 cm x10 cm) + GN (1:1) (2742 kg/ha) and PM (45 cm x10 cm) + GN (1:2) (2677 kg/ha). The highest groundnut equivalent yield was produced by PM (45 cm x 10 cm) + GN (1:1), which might be due to the complementary interaction between pearl millet and groundnut. The results conform to the findings of Chaudhari et al. (2017).

Economics

The computed data of economics presented in Table 4 revealed that the highest cost of cultivation was recorded in PM (60 cm x10 cm) + GN (1:3) (Rs.69948/ha) followed by PM (45 cm x10 cm) + GN (1:2) (Rs. 67160/ha) and PM (30 cm x10 cm) + GN (1:1) (Rs. 62360/ha). The highest gross returns were obtained in PM (45 cm x10 cm) + GN (1:1) (Rs. 153620/ha) followed by PM (60 cm x10 cm) + GN (1:2) (Rs. 145481/ha). In the case of net return, PM (45 cm x10 cm) + GN (1:1) resulted in the highest value (Rs. 99860/ha) and it was followed by PM (60 cm x10 cm) + GN (1:2) (Rs. 85533/ha). The highest B:C ratio was recorded in PM (45 cm x10 cm) + GN (1:1) (1.86) over other treatments and exceptionally two treatments obtained the lowest B:C ratio, they were, PM (45 cm x10 cm) + GN (1:2) (0.99) and PM (60 cm x10 cm) + GN (1:3) (0.48). However, the lowest values were obtained in PM sole (45cm x 10cm) compared to all other treatments in case of cost of cultivation (Rs. 32060/ha), gross returns

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(Rs. 64240/ha) and net returns (Rs. 32180/ha). When pearl millet is intercropped with groundnut highest B:C ratio was noticed in PM (45 cm x10 cm) + GN (1:1) with maximum gross returns. Earlier researchers also reported similar findings (Maitra et al., 1999; Shwethanjali et al., 2018; Chaudhari et al., 2017).

Table 4. Effect of intercropping pearl millet and groundnut on Economics.

Treatments	Economics			B:C Ratio
	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net return (Rs/ha)	
PM sole (45cm x 10cm)	32060	64240	32180	1.00
GN sole (30 cm x 10 cm)	50460	131633	81173	1.61
PM (45 cm x10 cm) + GN (1:1)	53760	153620	99860	1.86
PM (45 cm x10 cm) + GN (1:2)	67160	133838	66678	0.99
PM (30 cm x10 cm) + GN (1:1)	62360	137092	74732	1.20
PM (30 cm x10 cm) + GN (2:2)	49948	106077	56128	1.12
PM (60 cm x10 cm) + GN (1:1)	49948	112148	62200	1.25
PM (60 cm x10 cm) + GN (1:2)	59948	145481	85533	1.43
PM (60 cm x10 cm) + GN (1:3)	69948	103184	33236	0.48
PM=Pearl millet; GN=Groundnut				

Conclusion

The study noted that intercropping pearl millet and groundnut increased overall productivity per unit area despite sole cropping of each crop yielding higher individual outputs. Analysis of various competition indices such as LER, ATER, RCC, aggressivity and CR demonstrated the advantage of intercropping systems over sole stands for resource utilization and land-use efficiency. Among the different mixed stands, intercropping pearl millet and groundnut in a 1:1 row ratio with a spacing of 45 cm × 10 cm for pearl millet proved the most efficient under South Odisha conditions. This system not only optimized the use of available resources but also resulted in higher total productivity and greater economic returns, making it a suitable and sustainable cropping system for South Odisha.

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Conflict of Interest

The authors declare no conflict of interest.

References

Arif, M., Kumar, A., & Pourouchottamane, R. (2022). Pearl millet and cluster bean intercropping for enhancing fodder productivity, profitability and land use efficiency. *Bangladesh Journal of Botany, 51*(1), 103-112. https://doi.org/10.3329/bjb.v51i1.58826

Chappa, L.R., Mugwe, J., Gitari, H.I., & Maitra, S. (2023). Upholding sunflower (*Helianthus annuus*) yield and profitability while maintaining soil fertility under intercropping with sunn hemp and mineral fertilizer application. *International Journal of Bioresource Sciences,10*(01), 31-49. https://doi.org/10.30954/2347-9655.01.2023.4

Chaudhari, D.T., Vekariya, P.D., Vora, V.D., Talpada, M.M., & Sutaria, G.S. (2017). Enhancing productivity of groundnut based intercropping systems under rainfed conditions of Gujarat. *Legume Research-An International Journal*, *40*(3), 520-525. https://doi.org/10.18805/lr.v0i0.7849.

Chaudhary, R., Gupta, S.K., Singh, M.K., & Kohli, A. (2020). Effect of intercropping on growth, yield and profitability of sorghum, pearl millet and cowpea. *Journal of Pharmacognosy and Phytochemistry, 9*(5S), 179-182. https://doi.org/10.22271/phyto.2020.v9.i5Sd.12576.

Dwivedi, A., Dev, I., Kumar, V., Yadav, R.S., Yadav, M., Gupta, D., & Tomar, S.S. (2015). Potential role of maize-legume intercropping systems to improve soil fertility status under smallholder farming systems for sustainable agriculture in India. *International Journal of Life Sciences Biotechnology and Pharma Research*, *4*(3), 145.

El-Aref Kh. A. O., Ahmed, H. A., & Abd-El-Hameed, W. M. (2019). Studies on intercropping peanut and cowpea on grain sorghum. *Minia Journal of Agricultural Research and Development*, *39*(1), 175-189. https://doi.org/10.21608/mjard.2019.226586

Gaikwad, D.J., Ubale, N.B., Pal, A., Singh, S., Ali, M. A., & Maitra, S. (2022). Abiotic stresses impact on major cereals and adaptation options - A review. *Research on Crops*, *23*(4), 896-915. https://doi.org/10.31830/2348-7542.2022.ROC-913

Ghosh, P.K., Bandyopadhyay, K.K., Wanjari, R.H., Manna, M.C., Misra, A.K., Mohanty, M., & Rao, A.S. (2007). Legume effect for enhancing productivity and nutrient use-efficiency in major cropping systems–an Indian perspective: a review. *Journal of Sustainable Agriculture, 30*(1), 59-86. https://doi.org/10.1300/J064v30n01_07

Gitari, H.I., Shadrack, N., Kamau, S., Karanja, N.N., Gachene, C.K., & Schulte-Geldermann, E. (2020). Agronomic assessment of phosphorus efficacy for potato (*Solanum tuberosum* L.) under legume intercrops. *Journal of Plant Nutrition*, *43*(6), 864-878. https://doi.org/10.1080/01904167.2019.1702202

GOI (2021). Agricultural Statistics at a Glance. 2021. Ministry of Agriculture & Farmers Welfare Department of Agriculture, Cooperation & Farmers Welfare Directorate of Economics and Statistics, Government of India. pp. 62

Gomez, K.A., and Gomez, A.A. (1984). *Statistical Procedures for Agricultural Research*. John Wiley & sons.

GoO. (2020). Odisha Agriculture Statistics Report. Bhubaneswar: Directorate of Agriculture & food Production, Odisha, 2020.

Guntamukla, M., Sairam, M., Maitra, S., Gaikwad, D., Anuradha, N., Sahoo, U., & Pal, S. (2024). Performance Evaluation of Different Finger Millet (*Eleusine coracana* L. Gaertn.) Cultivars for Growth, Productivity and Nutrient Quality of Grains Under Hot and Subhumid Region of Odisha. *International Journal of Experimental Research and Review*, *39*(Spl Volume), 1-14. https://doi.org/10.52756/ijerr.2024.v39spl.001

Hemasree, K. R., Sairam, M., Maitra, S., Ray, S., Maheswari, N., Gaikwad, D. J., & Santosh, D.T. (2025). Effects of sulphur and zinc on growth and productivity of summer cowpea under conditions of southern Odisha. *Crop Research, 60*, 28-34. https://doi.org/10.31830/2454-1761.2025.cr-1012.

Hussainy, S.A.H., Brindavathy, R., & Vaidyanathan, R. (2020). Production potential of groundnut (*Arachis hypogaea* L.) under intercropping system-A review. *Crop Research, 55*(1&2), 36-47. https://doi.org/10.31830/2454-1761.2020.010

Hussainy, S.A.H., & Vaidyanathan, R. (2019). Potential yield of groundnut (*Arachis hypogaea*) based intercropping system as influenced by different irrigation regimes. *Pharma Innovation, 8*, 679-81.

Khan, M.A.H., Sultana, N., Akhtar, S., Akter, N., & Zaman, M.S. (2017). Performance of intercropping groundnut with sesame. *Bangladesh Agronomy Journal*, *20*(1), 99-105. https://doi.org/10.3329/baj.v20i1.34888

Lal, J., Meena, R.N., Kumar, S., Meena, R., Pal, V.K., & Lawate, P. (2018). Effect of crop diversification on growth and yield of pearl-millet (*Pennisetum glaucum* L.) under custard apple (*Annona squamosa* L.) based rainfed agrihorti system. *Journal of Pure and Applied Micro-Biology*, *12*, 207-215. https://doi.org/10.22207/JPAM.12.1.26

Maitra, S., Sahoo, U., Sairam, M., Gitari, H.I., Rezaei-Chiyaneh, E., Battaglia, M.L., & Hossain, A. (2023a). Cultivating sustainability: A comprehensive review on intercropping in a changing climate. *Research on Crops*, *24*(4), 702-715. https://doi.org/10.31830/2348-7542.2023.ROC-1020

Maitra, S. (2020). Intercropping of small millets for agricultural sustainability in drylands: A review. *Crop Research, 55*, 162-71. https://doi.org/10.31830/2454-1761.2020.025

Maitra, S. (2023). Intercropping System: Theory and Practices, NIPA GENX Electronic Resources and Solutions P. Ltd., p. 150, Available online: https://www.nipabooks.com/info/9789394490420/intercropping-system-theory-and-practices

Maitra, S., & Ray, D.P. (2019). Enrichment of biodiversity, influence in microbial population dynamics of soil and nutrient utilization in cereal-legume intercropping systems: A Review. International Journal *of Biological Sciences*, *6*(1), 11–19. https://doi.org/10.30954/2347-9655.01.2019.3

Maitra, S., Barik, A., Samui, S.K., & Saha, D., (1999). Economics of cotton based intercropping system in the rice fallows of coastal Bengal-Sundarbans. *Journal of Indian Society of Coastal Agricultural Research*, *17*(1-2), 299-304. https://doi.org/10.30954/2347-9655.02.2020.2

Maitra, S., Ghosh, D.C., Sounda, G., & Jana, P.K. (2001a). Performance of inter-cropping legumes in finger millet (*Eleusine coracana*) at varying fertility levels. *Indian Journal of Agronomy*, *46*(1), 38–44. https://doi.org/10.59797/ija.v46i1.3216

Maitra, S., Ghosh, D.C., Sounda, G., Jana, P.K., & Roy, D.K. (2000). Productivity, competition, and economics of intercropping legumes in finger millet (*Eleusine coracana*) at different fertility levels. *Indian Journal of Agricultural Science*, *70*, 824–828.

Maitra, S., Hossain, A., Bestir, M., Skalicky, M., Ondrisik, P., Gitari, H., Brahmachari, K., Shankar, T., Bhadra, P., Palai, J.B., Jena, J., Bhattacharya, U., Duvvada, S.K., Lalichetti, S., & Sairam, M. (2021). Intercropping – a low input agricultural strategy for food and environmental security. *Agronomy*, *11*(2), 343. https://doi.org/10.3390/agronomy11020343

Maitra, S., Palai, J.B., Manasa, P., & Kumar, D.P. (2019). Potential of intercropping system in sustaining crop productivity. *International Journal of Agriculture, Environment, and Biotechnology*, *12*, 39–45. https://doi.org/10.30954/0974-1712.03.2019.7

Maitra, S., Praharaj, S., Brestic, M., Sahoo, R.K., Sagar, L., Shankar, T., Jnana Bharati Palai, J. B., Sahoo, U., Sairam, M., Pramanick, B., Nath, S., Venugopalan, V.K., Skalický, M., & Hossain, A. (2023b). Rhizobium as biotechnological tools for green solutions: An environment-friendly approach for sustainable crop production in the modern era of climate change. *Current Microbiology*, *80*, 219. https://doi.org/10.1007/s00284-023-03317-w.

Maitra, S., Samui, S.K., Roy, D.K., & Mondal, A.K. (2001b). Effect of cotton based intercropping system under rainfed conditions in Sundarban region of West Bengal. *The Indian Journal of Agricultural Sciences*, *45*,157–162.

Maitra, S., Shankar, T., & Banerjee, P. (2020). Potential and advantages of maize-legume intercropping system, In Maize Production and Use; Hossain, A., Ed.; Intechopen, London, United Kingdom. https://doi.org/10.5772/intechopen.91722

Manasa, P., Sairam, M., & Maitra, S. (2021). Influence of Maize-Legume Intercropping System on Growth and Productivity of Crops, *International Journal of Bioresource Science*, *8*(1), 47–60. https://doi.org/10.30954/2347-9655.01.2021

Mandal, B.K., Dhara, M.C., Mandal, B.B., & Patra, B.C. (1989). Growth of rice, mung bean, soybean, peanut, rice bean and black gram as sole and intercrops. *Indian Journal of Plant Physiology*, *32*(4), 294-298.

Mir, M.S., Saxena, A., Kanth, R. H., Raja, W., Dar, K. A., Mahdi, S. S., & Mir, S. A. (2022). role of intercropping in sustainable insect-pest management: A Review. *International Journal of Environment and Climate Change*, *12*(11), 3390-3403. https://doi.org/10.9734/ijecc/2022/v12i111390

Mohamed, A.M.E., Ibrahim, M.M., El-Said, M.A.A., & Mahdy, A.Y. (2020). Effect of intercropping cow pea with pearl millet on forage yield and competitive relationships. *Archives of Agriculture Sciences Journal*, *3*(3), 101-116. https://doi.org/10.21608/aasj.2020.43889.1039

Mukesh, G., Sairam, M., Maitra, S., Gaikwad, D. J., Sagar, L., & Ray, S. (2024). Agrometeorological indices, physiological growth parameters and performance of finger millet as influenced by different cultivars under hot and sub humid region of Odisha. *International Journal of Experimental Research and Review*, *42*, 148-161. https://doi.org/10.52756/ijerr.2024.v42.013

Nandi, S., Sairam, M., Panda, M., Shankar, T., & Maitra, S. (2022). Dry Matter Accumulation, Yield and Economics of Maize Cultivation as Influenced by Mixed Stands of Maize+ Vegetable Legumes. *International Journal of Bioresource Science*, *9*(02), 93-100. https://doi.org/10.30954/2347-9655.02.2022.5

Priya, G. S., Maitra, S., Shankar, T., & Sairam M. (2023). Effect of the summer pearl millet-groundnut intercropping system on the growth, productivity, and competitive ability of crops under south Odisha conditions. *Plant Science Today*, *10*(4), 238–246. https://doi.org/10.14719/pst.2627

Raman, M.V., Kumar, K.A., & Reddy, B.B. (1991). Studies on dry matter accumulation and nutrient uptake in groundnut and pigeon pea intercropping. *Journal of Research APAU (India)*.

Rani, S., Goyat, R., & Soni, J.K. (2017). Pearl millet [*Pennisetum glaucum L.*] intercropping with pulses step towards increasing farmer's income under rainfed farming: A review. *The Pharma Innovation Journal*, *6*(10), 385-390.

Rawat, B., Kumar, R., Kamboj, N.K., Gupta, G., & Jain, B.T. (2017). Nutrient Management in Pearl Millet Based Intercropping Systems under Rainfed Situations. *Research Journal of Agricultural Sciences*, *8*(5), 1118-1121.

Ray, S., Maitra, S., Sairam, M., Sameer, S., Sagar, L., Divya, B. S., & Gitari, H. I. (2025). The nexus between intercropping systems, ecosystem services and sustainable agriculture: A review. *Research on Crops*, *26*(1), 1-11. https://doi.org/10.31830/2348-7542.2025.ROC-1166.

Sairam, M., Maitra, S., Praharaj, S., Nath, S., Shankar, T., Sahoo, U., Santosh, D.T., Sagar, L., Panda, M., Shanthi Priya, Ashwini, T.R., Gaikwad, D.J., Hossain, A. Pramanick, B., Jatav, H.S., Gitari, H.I., & Aftab, T. (2023). An insight into the consequences of emerging contaminants in soil and water and plant responses. In: Aftab, T. (eds.), Emerging

Contaminants and Plants Interactions, Adaptations and Remediation Technologies, pp.1–27.

Santosh, D. T., Debnath, S., Maitra, S., Sairam, M., Sagar, L. L., Hossain, A., & Moulick, D. (2024). Alleviation of climate catastrophe in agriculture through adoption of climate-smart technologies. In: Chatterjee, U., Shaw, R., Kumar, S., Raj, A.D. and Sandipan Das, S. (eds.) Climate Crisis: Adaptive Approaches and Sustainability. Springer Nature Switzerland. pp. 307-32.

Sarkar, R.K., Shit, D., & Maitra, S. (2000). Competition functions, productivity and economics of chickpea (*Cicer arietinum*)-based intercropping system under rainfed conditions of Bihar plateau. *Indian Journal of Agronomy*, *45*(4), 681-686.
https://doi.org/10.59797/ija.v45i4.3429

Shwethanjali, K.V., Naik, A.K., Basavaraj Naik, T., & Dinesh Kumar, M. (2018). Effect of groundnut+ millets inter-cropping system on yield and economic advantage in central dry zone of Karnataka under rainfed condition. *International Journal of Current Microbiology and Applied Science*, *7*(9), 2921-2926.
https://doi.org/10.20546/ijcmas.2018.709.363

Triveni, B., Babu, A.M., Reddy, G.P., & Munaswamy, V. (2017). Effect of intercropping systems on yield attributes and yield of pearlmillet with grain legumes under rainfed conditions. *International Journal of Current Microbiology and Applied Science*, *6*(11), 3567-3571.
https://doi.org/10.20546/ijcmas.2017.611.418

Yadav, B.L., Patel, B.S., Ali, S., & Yadav, S.K. (2015). Intercropping of legumes and oil seed crop in summer pearlmillet (*Pennisetum glaucum* (L.) R. Br. Emend. Stuntz). *Legume Research-An International Journal*, *38*(4), 503-508.
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